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Pre-paid Energy Meter based on AVR Microcontroller

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ABSTRACT

The present system of energy billing in India is error prone and also time and labor consuming. Errors get introduced at every stage of energy billing like errors with electro-mechanical meters, human errors while noting down the meter reading and error while processing the paid bills and the due bills. There are many cases where the bill is paid and then is shown as a due amount in the next bill. There is no proper way to know the consumer's maximum demand, usage details, losses in the lines, and power theft. The remedy for this drawback is prepaid energy billing, which could be titled. Pay first and then use it. There are clear results from many countries, where prepaid system has reduced the usage (wastage) by a large amount. Another advantage of the prepaid system is that the human errors made reading meters and processing bills can be reduced to a large extent. Many works in the field of prepaid meter have already been done but they have used 8051 controller for their operation. In this paper, the idea of pre-paid energy meter using AVR controller have been introduced. In this method 8051 has been replaced by AVR controller because, it is energy efficient i.e. it consume less power, it is fastest among all the microcontroller families, it has inbuilt ADC and have advanced RISC architecture. In this paper, energy meters have not been replaced which is already installed at our houses, but a small modification on the already installed meters can change the existing meters into prepaid meters, so this meters are very cheaper. The use of GSM module provides a feature of pre-paid through SMS. One can recharge meter with the help of mobile through SMS, on the basis of recharge amount, AVR controller count the amount of energy consumed and display the remaining amount of energy on the LCD. If the amount falls below certain minimum amount, then it will be indicated by the controller through buzzer.

Keywords - **AVR *controller, GSM module, ULN2003 drivers, relays, Bascom.***

I. INTRODUCTION

The present billing system is minimally able to detect power theft and even when it does it is at the end of the month. Also, the distribution company is facing many problems in terms of losses. The distribution company is unable to keep track of the changing maximum demand for domestic consumers. The consumer is facing problems like receiving due bills for bills that have already been paid as well as poor reliability of electricity supply and quality even if bills are paid regularly. The remedy for all these problems is to keep track of the consumers load on a timely basis, which will help assure accurate billing, track maximum demand, and detect online theft. These are all the features to be taken into account for designing an efficient energy billing system. The present project 'AVR Microcontroller based prepaid energy meter' for India. Incorporate these features to address the problems faced by both the consumers and the distribution companies.

The paper mainly deals with pre-paid energy meter [1] which utilizes the features of embedded system which is the combination of hardware and software in order to implement desired functionality . The next session of the paper discuss comparison between different Microcontrollers and the compiler used to program the Microcontroller [3]. The final session of the paper discuss with the application of GSM Modem to introduce pre paid concept. With the use of GSM modem one can recharge the energy meter with the help of mobile. Also the amount left for usage will be continuously displayed on the LCD and if the amount fall below certain minimum value then it can be indicated with the help of buzzer.

II. EMBEDDED SYSTEM

An Embedded System is designed to perform some dedicated function. A combination of hardware and software, it forms an embedded part of a complete device. Since an Embedded system has a limited range of applications, design engineers face no problem to optimize both size and cost or enhance reliability and quality of performance [4]. Embedded systems range from portable devices such as digital watches and MP3 players, to large stationary installations like traffic lights, factory controllers, or the systems controlling nuclear power plants. Complexity varies from low, with a single microcontroller chip, to very high with multiple units, peripherals and networks mounted inside a large chassis or enclosure. Typically, embedded systems are Reactive and Real time systems. A Reactive system is one, which is in continual interaction with its environment and executes at a pace determined by that environment. The functioning of a digital camera can be taken as an example for Real time and Reactive Embedded systems. Embedded Systems will play a key role to drive the technological evolution in the next decades. In this respect they stand on the same level as nano technologies, bioelectronics, and photonics. The central role of embedded systems in the economy grows stronger and stronger. The starting point is the convergence between storage, security, video, audio, mobility and connectivity. Systems are converging and ICs are more and more converging with systems. This poses a number of challenges for designers and technologists. A key issue is the definition of the right methodologies to translate system knowledge and competences into complex embedded systems, taking into account many system requirements and constraints. The key factor to win this challenge is to build the right culture. This means to be able to build the right environment to exploit existing design, architectural and technological solutions, and to favor the transfer of knowledge from one application field into another.

III. AVR MICROCONTROLLER

The AVR is a modified Harvard architecture 8-bit RISC single chip microcontroller which was developed by Atmel in 1996. The AVR was one of the first microcontroller families to use on-chip flash memory for program storage, as opposed to One-Time Programmable ROM, EPROM, or EEPROM used by other microcontrollers at the time. The AVR architecture was conceived by two students at the Norwegian Institute of Technology (NTH) Alf-Egil Bogen and Vegard Wollan. The original AVR MCU was developed at a local ASIC house in Trondheim, Norway called Nordic VLSI at the time, now Nordic Semiconductor, where the two founders of Atmel Norway were working as students. It was known as a µRISC and was available as silicon IP/building block from Nordic VLSI [2]. When the technology was sold to Atmel from Nordic VLSI, the internal architecture was further developed by Alf and Vegard at Atmel Norway, a subsidiary of Atmel founded by the two architects. The designers worked closely with compiler writers at IAR Systems to ensure that the instruction set provided for more efficient compilation of high-level languages. Atmel says that the name AVR is not an acronym and does not stand for anything in particular. The creators of the AVR give no definitive answer as to what the term "AVR" stands for. However, it is commonly accepted that AVR stands for **A**lf (Egil Bogen) and **V**egard (Wollan)'s **R**isc processor".

A. Features Of AVR microcontroller 8535[5]

High-performance, Low-power AVR 8-bit Microcontroller

1. Advanced RISC Architecture
   - 130 Powerful Instructions – Most Single Clock Cycle Execution
   - 32 x 8 General Purpose Working Registers
   - Fully Static Operation
   - Up to 16 MIPS Throughput at 16 MHz
   - On-chip 2-cycle Multiplier
2. Nonvolatile Program and Data Memories
   - 8K Bytes of In-System Self-Programmable flash
3. Endurance: 10,000 Write/Erase Cycle
4. In-System Programming by On-chip Boot Program
5. True Read-While-Write Operation
   - 512 Bytes EEPROM
   - 512 Bytes Internal SRAM
6. Peripheral Features
   - Two 8-bit Timer/Counters with Separate Prescalers and Compare Modes
   - One 16-bit Timer/Counter with Separate Prescaler, Compare Mode, and Capture mode
   - Real Time Counter with Separate Oscillator
   - Four PWM Channels
   - 8-channel, 10-bit ADC
   - Byte-oriented Two-wire Serial Interface
   - Programmable Serial USART
   - Master/Slave SPI Serial Interface
   - Programmable Watchdog Timer with Separate On-chip Oscillator
   - On-chip Analog Comparator
7. Special Microcontroller Features
   - Power-on Reset and Programmable Brown-out Detection
   - Internal Calibrated RC Oscillator
   - External and Internal Interrupt Sources
   - Six Sleep Modes: Idle, ADC Noise Reduction, Power-save, Power-down, Standby and Extended Standby
8. I/O and Packages
   - 32 Programmable I/O Lines
   - 40-pin PDIP, 44-lead TQFP, 44-lead PLCC, and 44-pad QFN/MLF
9. Operating Voltages
   - 2.7 - 5.5V for ATmega8535L
   - 4.5 - 5.5V for ATmega8535
10. Speed Grades
    - 0 - 8 MHz for ATmega8535L
    - 0 - 16 MHz for ATmega8535

B. Why AVR Family?

8051

- 8 bit micro based on CISC architecture
- 8051 family is slower as compared to AVR
- Doesn't have a ADC
- Instruction set is too large
- JTAG interface absent

AVR

- 8 bit micro based on RISC architecture
- AVR's are faster, consume little power and rugged
- It has an inbuilt 10-bit ADC
- Instruction set simple and compact
- JTAG interface present

C. Internal Architecture of AVR Microcontroller

The ATmega8535 is a low-power CMOS 8-bit microcontroller based on the AVR enhanced RISC architecture, by executing instructions in a single clock cycle, ATmega8535 achieves throughput approaching 1 MIPS per MHz allow the system manufacturer to optimize power consumption versus processing speed internal architecture of AVR microcontroller has been shown in Fig 1.

IV. ENERGY METER

An electric meter or energy meter is a device that measures the amount of electrical energy consumed by a residence, business, or an electrically-powered device. Electric meters are typically calibrated in billing units, the most common one being the kilowatt hour. Periodic reading of electric meters establishes billing cycles and energy used during a cycle. In settings when energy savings during certain periods are desired, meters may measure demand, the maximum use of power in some interval [9]. In some areas, the electric rates are higher during certain times of day, to encourage reduction in use. Also, in some areas meters have relays to turn off non-essential equipment. The most common unit of measurement on the electricity meter is the kilowatt hour, which is equal to the amount of energy used by a load of one kilowatt over a period of one hour, or 3,600,000 joules. Reactive power is measured in 'volt-amperes reactive', (varh) in kilovar-hours. By convention, a 'lagging' or inductive load, such as a motor, will have positive reactive power. A 'leading' or capacitive load will have negative reactive power. Volt-amperes measures all power passed through a distribution network, including reactive and actual. This is equal to the product of root-mean-square volts and amperes. The meters fall into two basic categories, electromechanical and electronic [4]. The electromechanical induction meter operates by counting the revolutions of an aluminum disc which is made to rotate at a speed proportional to the power. The number of revolutions is thus proportional to the energy usage. It consumes a small amount of power, typically around 2 watts.

V. PRE-PAID ENERGY METERS

Pre-paid energy meter allows consumer to first pay the amount and then use the electricity. There are clear results from many countries, where a prepaid system has reduced the usage (wastage) by a large amount. Another advantage of the pre-paid system is that the human errors made reading meters and processing bills can be reduced to a large extent [7].

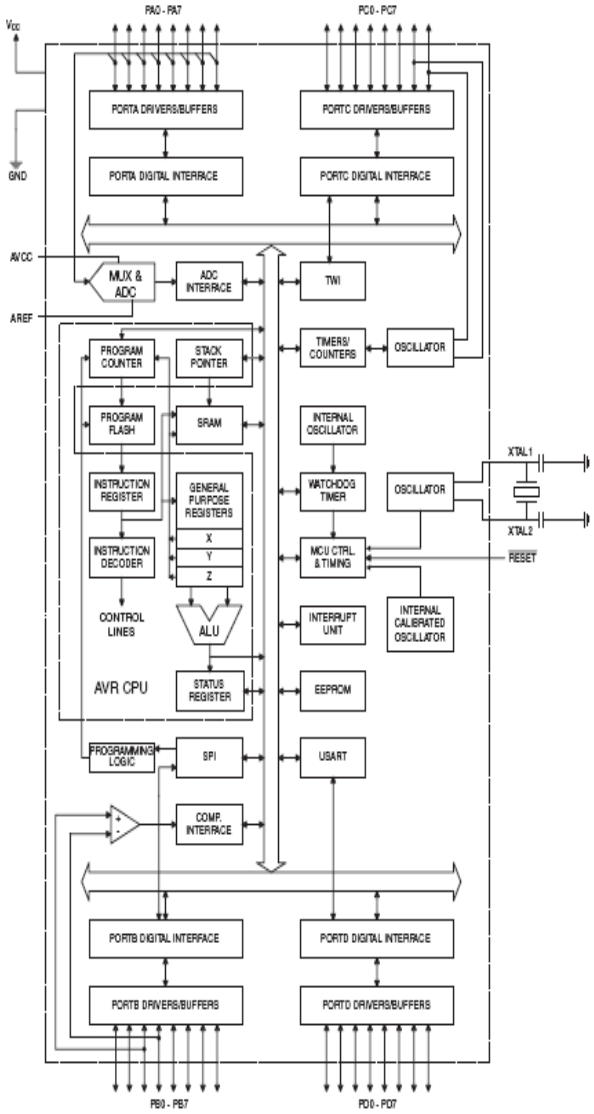

Fig 1. Internal Architecture of AVR Microcontroller

A. Circuit Descriptions

The pre-paid functionality can be implemented using an electronic meter, which consists of LED, which is a blink according to the power consumption. If the consumption is more then LED will blink with a faster rate but if consumption is less then LED will blink with slower rate .

The LED is receiving train of pulses which is responsible for it's blinking. This train of pulses is applied to one of the interrupt pin of AVR controller. The counter is activated at the interrupt pin, which counts the number of pulses that AVR controller is receiving and thus controller measure the amount of energy consumed in the household [2]. The help of GSM modem one can embed a feature of pre-paid through mobile, with the help of GSM modem one can recharge energy meter through mobile by SMS. The GSM modem loads the recharge amount in one of the register of controller. For each pulses received at interrupt pin, the controller decrement the content of the register which is equivalent to the recharged amount left. If the content of the register falls below some level the controller activate the buzzer which indicate that amount left in the meter is low. If the contents of the register becomes zero then with the help of relay driver controller drive the relay which will disconnect the supply from the household. On recharging the meter the controller connect the supply to the load with the help of relays. Thus prepaid energy meter controls the power supplied to the household on the basis of amount available to the meter. The LCD is also connected with the controller which displays the amount to be available for usage.

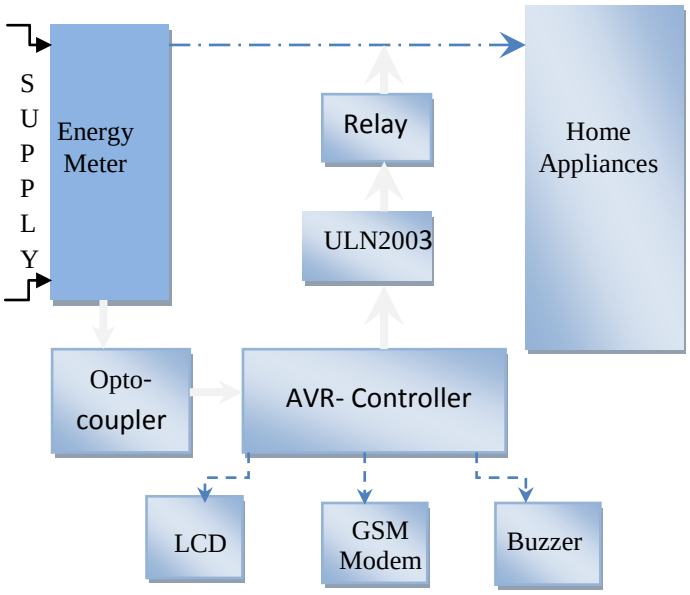

Fig 2. Circuit descriptions of AVR Microcontroller

B. Bascom Compiler

Bascom is an Integrated Development Environment (IDE) that supports the 8051 family of microcontroller as well as family of AVR microcontroller. Two products are available in the market for various microcontroller- BASCOM-8051 and BASCOM-AVR [6]. BASCOM-AVR is not only a basic compiler but also a comfortable IDE running under Windows 95 and Windows NT. Bascom AVR is a compiler that converts basic program language into hexa code that you can program your microcontroller with. Bascom AVR also has a build in programmer to program your microcontroller. Key features of Bascom Compiler are

- Structured BASIC with labels.
- Structured programming with IF-THEN-ELSE-END IF, DO-LOOP, WHILE-WEND, SELECT- CASE.
- Fast machine code instead of interpreted code.
- Variables and labels can be as long as 32 characters.
- Bit, Byte, Integer, Word, Long, Single and String variables.
- Large set of Trig Floating point functions. Date & Time calculation functions.
- Compiled programs work with all AVR microprocessors that have internal memory.
- Statements are highly compatible with Microsoft's VB/QB.
- Special commands for LCD-displays, I2C chips and 1WIRE chips, PC keyboad, matrix keyboad, RC5 reception, software UART, SPI, graphical LCD, send IR RC5, RC6 or Sony code. TCP/IP with W3100A chip.
- Local variables, user functions, library support.
- Integrated terminal emulator with download option.
- Integrated simulator for testing.
- Integrated ISP programmer (application note AVR910.ASM).
- Many other programmers supported via the Universal Interface.
- Editor with statement highlighting.
- Context sensitive help.
- DEMO version compiles 4KB of code. Well suited for the AT90S2313.
- Special TCP/IP library, AT mouse simulator, AT keyboard simulator available as add-ons.

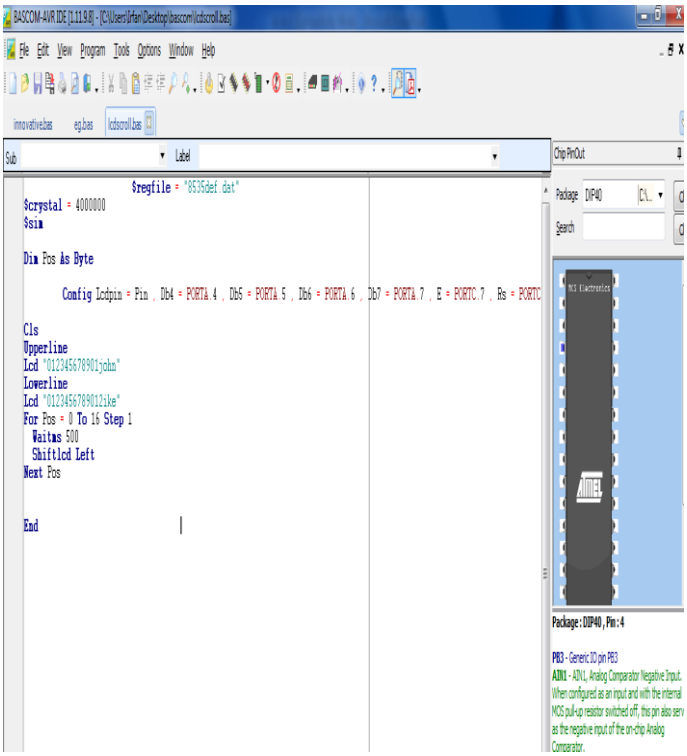

Fig 3. Bascom AVR IDE

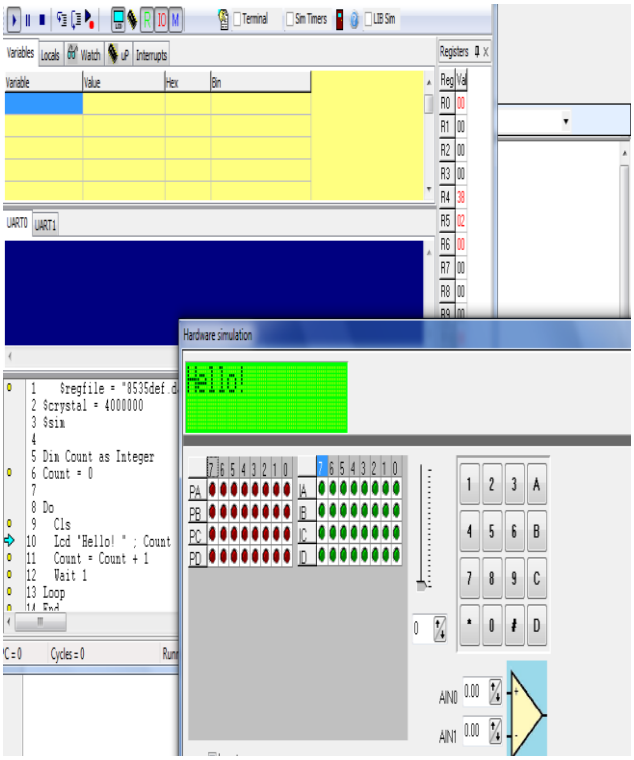

Fig 4. Bascom Simulator

C. GSM Module

GSM module is mainly used to introduce the pre-paid concept in energy meter. GSM which stands for Global System for Mobile Communication is widely used mobile communication architecture used in most of the countries. The transmit pin (Tx) of the microcontroller's serial port is connected with the receive pin (Rx) of the GSM module [7]. The transmit pin (Tx) of the of GSM module is connected to receive pin (Rx) of microcontroller's serial transmission pin. Therefore the commands and their results are transmitted and received in a triangular fashion. The controller can receive data signals either by polling or by making use of serial interrupt (ES). The module that we use for GSM is SIM300 mini GSM Module for Communication. We basically use this modem for Text sending and Receiving. The voice pin in this modem is shorted and thus cannot be used. The AT short for ATtension commands are used to communicate with this modem. It works from 3.6 - 4.6V maximum and consumes 250mA current in normal mode which can increase upto 1A when transmitting. It needs a heat sink in order to dissipate the heat that is developed.

D. AT commands

AT commands are instructions used to control a modem. AT is the abbreviation of ATtention. Every command line starts with "AT" or "at". That's why modem commands are called AT commands [8]. Many of the commands that are used to control wired dial-up modems, such as ATD (Dial), ATA (Answer), ATH (Hook control) and ATO (Return to online data state), are also supported by GSM/GPRS modems and mobile phones. Besides this common AT command set, GSM/GPRS modems and mobile phones support an AT command set that is specific to the GSM

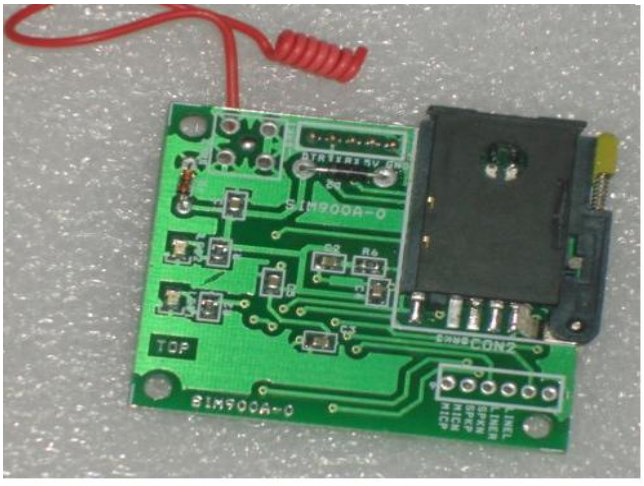

Fig 5. Front view

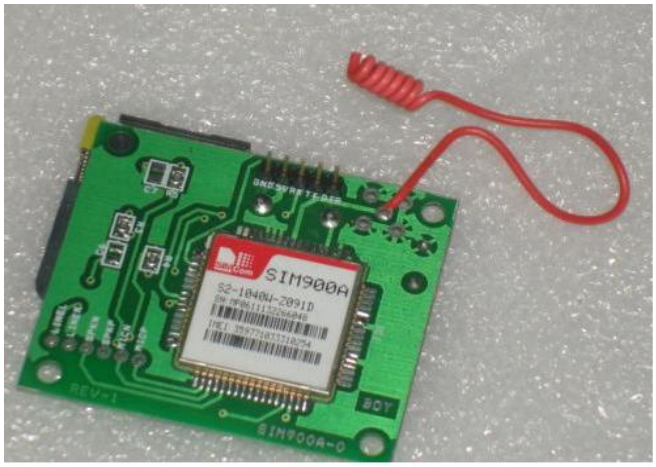

Fig 6. Back view

Technology, which includes SMS-related commands like AT+CMGS (Send SMS message), AT+CMSS (Send SMS message from storage), AT+CMGL (List SMS messages) and AT+CMGR (Read SMS messages). There are two types of AT commands: basic commands and extended commands. Basic commands are AT commands that do not start with "+". For example, D (Dial), A (Answer), H (Hook control) and O (Return to online data state) are basic commands. Extended commands are AT commands that start with "+". All GSM AT commands are extended commands. For example, +CMGS (Send SMS message), +CMSS (Send SMS message from storage), +CMGL (List SMS messages) and +CMGR (Read SMS messages) are extended commands

VI. CONCLUSION

Paper is intended to present an overview of pre-paid energy meter, which can control the usage of electricity on consumer side to avoid wastage of power. Since there is need to utilize energy in better and efficient way, so this pre-paid meter proves to be a boon in the power sector. The major drawback of a post paid system is that there is no control of usage from the consumer's side. There is a lot of wastage of power due to the consumer's lack of planning of electrical consumption in an efficient way. Since the supply of power is limited, as a responsible citizen, there is a need to utilize electricity in a better and efficient way. The distribution company has to receive huge amounts in the form of pending bills, which results in substantial revenue losses and also hurdles to modernization because of lack of funds. The billing system is minimally able to detect power theft and even when it does at the end of the month. Also, the distribution company is facing many problems in terms of losses. The distribution company is unable to keep track of the changing maximum demand for domestic consumers. The consumer is facing problems like receiving due bills for bills that have already been paid as well as poor reliability of electricity supply and quality even if bills are paid regularly. The remedy for all these problems is to keep track of the consumers load on a timely basis, which will help assure accurate billing, track maximum demand, and detect online theft. These are all the features to be taken into account for designing an efficient energy billing system. The present project incorporates these features to address the problems faced by both the consumers and the distribution companies.

REFERENCES

[1] Syed Khizar Ali Zaidi I, Hura Masroor I, Syed Rehan Ashraf I and Ahmed Hassan, "Design and Implementation of Low Cost Electronic Prepaid Energy Meter", NED University of Engineering and Technology, Karachi, Pakistan, 2010.

[2] Atmel Corporation - Atmel AVR 8- and 32-bit Microcontrollers http://www.atmel.com/products/AVR/

[3] Prepaid electricity billing system using GSM mobile http://www.seminarprojects.com/Thread-prepaid-energy-meter-using-gsm-mobile#ixzz1BUylZEck

[4] Mazidi. Mohammed Ali and Janice Gillespie Mazidi. "The 8051 microcontroller and embedded systems", second edition, Prentice Hall Publications, 1999.

[5] The Atmel AVR, Microchip PIC, and TI MSP430 http://www.eg3.com/blog/20100101-timsp430-atmel-avr-microchip-pic.htm

[6] Bascom-AVR http://avrhelp.mcselec.com/index.html

[7] http://probots.co.in/Manuals/SIM300.pdf

[8] http://www.engineersgarage.com/tutorials/at-commands

[9] Saptarshi De, Rahul Anand, A Naveen and Sirat Moinuddin, "E-Metering Solution for checking energy thefts and streamlining revenue collection in India", Student Member, IEEE, 2003.

[10] Loss.P.A.V, Lamego. M.M and Vieira.J.L.F, "A single phase microcontroller based energy meter", IEEE Instrumentation and Measurements Technology conference St. Paul, Minessota, USA, May 18-21, 1998.

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